AIR FORCE Science & Technology Plan

2011

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14. ABSTRACT
The 2011 Air Force (AF) Science and Technology (S&T) Plan contains AFRL's response to the 2010 Air Force S&T Strategy. The plan contains S&T focus areas as well as objectives for each of the S&T strategy priorities.

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The Air Force depends on the S&T Program to discover, develop, and demonstrate high-payoff technologies needed to address the ever-changing strategic and operational environment and to sustain air, space, and cyberspace dominance across the near-, mid- and far-term.

SECRETARY OF THE AIR FORCE AND CHIEF OF STAFF OF THE AIR FORCE

As a leader in the military application of air, space, and intelligence, surveillance, and reconnaissance technology, the Air Force is committed to innovation to guide research, development, and fielding of unsurpassed capabilities. The Air Force nurtures and promotes its ability to translate our technology into operational capability—to prevail in conflict and avert technological surprise.

AIR FORCE DOCTRINE DOCUMENT 1

The United States Air Force finds itself at an undeniably pivotal time in its history. It is without question the most effective and powerful air force in the world and the only air force that can truly project global power. The single most important factor in achieving this position has been the unmatched technological advantage the Air Force has attained over its many competitors.

TECHNOLOGY HORIZONS

FOREWORD

In December 2010, the Secretary of the Air Force and the Chief of Staff of the Air Force released the "Air Force Science and Technology Strategy." This important document codified a new capability-based Air Force Science and Technology (S&T) vision, established strategic priorities, and provided guidance for balancing investments across the near-, mid- and far-term.

The 2011 Air Force Science and Technology Plan is a capstone document describing how the service's single research laboratory, the Air Force Research Laboratory (AFRL), will implement the new Air Force S&T strategy:

- Section 1 - reviews the overarching tenets driving the Air Force S&T Program
- Section 2 - summarizes the new Air Force S&T strategy
- Section 3 - describes the Air Force's disciplined approach to continuously transforming science and knowledge into new capabilities that are tailored to warfighter needs
- Section 4 - provides a high-level overview of key S&T increased emphasis areas that are critical to sustaining the Air Force's Service Core Functions (SCF)
- Section 5 - highlights how the Air Force S&T workforce is evolving to best support the service's needs
- Section 6 - outlines how the S&T Program is working with organizations from government, industry and academia to place affordable, war-winning capabilities in the hands of warfighters

Today's Air Force stands as the most powerful air, space and cyber force in the world because of past technological advances that have been transformed into revolutionary new capabilities. This plan reflects our continued commitment to strengthen the Service Core Functions by leading the discovery, development and demonstration of affordable, war-winning S&T-enabled capabilities for the Airmen of today and tomorrow.

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Science, Technology and Engineering

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Commander
Air Force Research Laboratory

TABLE OF CONTENTS

Section 1. Introduction.... 3

Section 2. Air Force Science & Technology Strategy Summary.....4

Section 3. Support Current Fight while Advancing Breakthrough Science & Technology.....5

Section 4. Increased Science & Technology Emphasis Areas.....11

Section 5. Retain and Shape Critical Competencies.....19

Section 6. Address Highest-Priority Capability Needs.....22

Section 7. Summary..... 25

SECTION 1

INTRODUCTION

The Air Force maintains a technological edge to deter, dissuade, and defeat potential threats in air, space and cyberspace. Service leadership has charged the Air Force S&T Program to:

- Prepare for an uncertain future and investigate game-changing technologies to affordably transition the art-of-the-possible into military capabilities
- Create technology options that address urgent warfighter needs and provide new capabilities in support of Air Force Service Core Functions
- Demonstrate advanced technologies that address affordability by promoting efficiencies, enhancing the effectiveness, readiness, and availability of today's systems, and addressing lifecycle costs of future systems
- Develop throughout the Air Force an appreciation for the value of technology as a force multiplier
- Maintain in-house expertise to support the acquisition and operational communities and modernize and improve the sustainability of unique research facilities and infrastructure
- Remain vigilant over and leverage global science and technology developments and emerging capabilities

The service's single research organization, the Air Force Research Laboratory (AFRL), executes the Air Force's investment portfolio in basic research, applied research and advanced technology development. AFRL works collaboratively with key S&T stakeholders to maintain a balanced portfolio responsive to current warfighter needs while simultaneously creating the technical foundation for the future force. The S&T planning process draws upon multiple sources, including:

- National security policy
- Quadrennial Defense Review
- National Security Space Strategy
- Service Core Function Master Plans
- "Technology Horizons"
- Threat assessments
- Major S&T studies
- Assistant Secretary of Defense for Research & Engineering guidance
- Industry perspectives

Air Force leadership used these and many other sources to formulate the Air Force S&T Strategy, which sets the strategic direction of the Air Force S&T Program. The following section summarizes this strategy.

AIR FORCE SCIENCE & TECHNOLOGY STRATEGY SUMMARY

SECTION 2

A broad spectrum of threats seeks to limit the nation's ability to project global reach, global power, and global vigilance. The nation depends on the Air Force to counter these threats and the Air Force relies on the S&T program to provide the technical edge required to affordably meet mission needs across the near-, mid- and far-term.

The Air Force's strategic S&T priorities are:

1. *Support the current fight while advancing breakthrough S&T for tomorrow's dominant warfighting capabilities*
2. *Execute a balanced, integrated S&T Program that is responsive to Air Force Service Core Functions*
3. *Retain and shape the critical competencies needed to address the full range of S&T product and support capabilities*
4. *Ensure the Air Force S&T Program addresses the highest priority capability needs of the Air Force*

Many inputs must be considered when shaping a balanced S&T portfolio, inputs that provide guideposts for resource decisions. Based on the current set of guideposts, additional S&T emphasis is being directed to:

- Improve the sustainment, affordability and availability of legacy systems
- Reduce cyber vulnerabilities while emphasizing mission assurance
- Support the needs of the nuclear enterprise
- Develop the autonomous system technologies envisioned in "Technology Horizons"
- Develop human performance augmentation technologies envisioned in "Technology Horizons"
- Provide robust situational awareness to enhance decision-making by improving intelligence, surveillance and reconnaissance (ISR) capabilities and data processing, exploitation and dissemination
- Enable long-range precision strike
- Reduce energy dependency

To meet the nation's needs, the Air Force invests across a broad portfolio to attain balance between the warfighter's need for near-term, rapid-reaction solutions; mid-term technology development; and revolutionary, far-term capabilities. The following section summarizes the scope of Air Force S&T Program activities and highlights key technology transition efforts in each phase of the S&T life cycle.

SECTION 3

SUPPORT CURRENT FIGHT WHILE ADVANCING BREAKTHROUGH SCIENCE & TECHNOLOGY

The Air Force depends on its S&T Program to discover, develop, and demonstrate affordable, high-payoff technologies needed to sustain air, space, and cyberspace superiority in an increasingly competitive environment. The S&T Program ensures the Air Force maintains a winning edge by continuously transitioning critical products that strengthen Air Force Service Core Functions. As shown in *Figure 1*, the Air Force S&T Program:

- Advances high-risk/high-return Science and Knowledge to reduce service future risk
- Matures affordable technologies to address specific warfighter needs
- Demonstrates high-value S&T enabled capabilities that reduce acquisition risk
- Provides quick-reaction support to operational forces

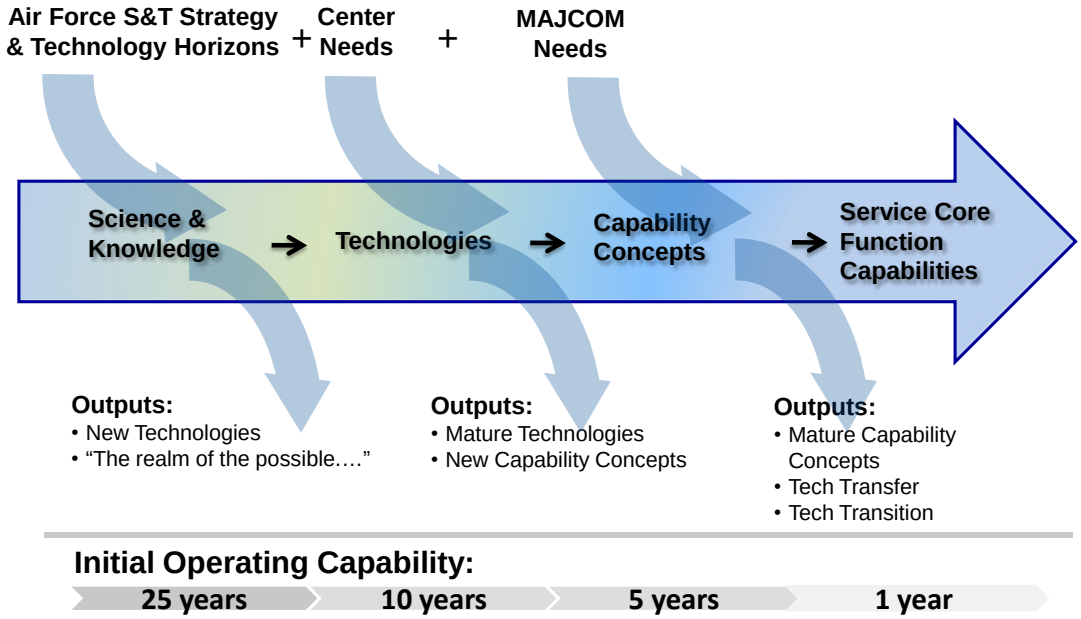


Figure 1. S&T Life Cycle

The following pages broadly summarize Air Force S&T Program activities across the S&T life cycle. These integrated activities provide full-spectrum support to the Air Force Service Core Functions across the near-, mid- and far-term. Benefits to the Service Core Functions include increased capabilities, enhanced affordability, improved sustainability, and reduced risk.

3.1 SCIENCE AND KNOWLEDGE

Science and knowledge are the foundation of the Air Force S&T Program and the cornerstone of the future force. Based on visions of the future established by Air Force leadership, Air Force scientists and engineers identify, nurture, and harvest the best basic research to transform leading-edge scientific discoveries into new technologies with substantial military potential.

The Air Force S&T Program is advancing the following science and knowledge areas in support of the Service Core Functions, Air Force S&T Strategy, and "Technology Horizons" vision:

SCIENCE AND KNOWLEDGE AREA	FOCUS
Aerospace, Chemical and Material Sciences	Aero-structure interactions and control; energy, power and propulsion; complex materials and structures
Physics and Electronics	Complex electronics and fundamental quantum processes; plasma physics and high energy density nonequilibrium processes; optics, electromagnetics, communications and signal processing
Mathematics, Information and Life Sciences	Information and complex networks; decision making; natural materials and systems; dynamical systems, optimization and control

With its scientists and engineers actively engaged in worldwide technical communities, the Air Force is also able to leverage significant investments made by other defense and federal agencies, as well as non-defense and international laboratories. This combination of Air Force investment and global partnerships enables the Service to advance basic science that leads to opportunities such as:

- **Cold atoms** – may enable development of an inertial navigation on a chip that is jam-proof, non-emanating, stand-alone, and highly accurate
- **Self-healing structures** – ability to engineer high-efficiency self-healing polymeric composites potentially leading to more durable and longer-lasting aircraft structures.
- **Morphing aircraft structures** – enabling structures capable of altering their shape, functionality and mechanical properties for real-time conditions would give the Air Force the ability for superior performance anytime, anywhere
- **Bendable electronics** – fast, super-flexible silicon chips to attach to unevenly shaped objects and can withstand impact and severe vibration, conduct current, deflect radar or serve as antennae
- **Bending lasers** – research to create curved laser beams to accelerate charged particles and guide high-power microwaves and radiofrequency waves in the air
- **Bioenergy –** developing renewable biosolar hydrogen techniques and algal oil accumulation to propel vehicles as well as refining artificial photosynthesis for the bioengineering of solar and microbial fuel cells for electricity

3.2 AFFORDABLE TECHNOLOGIES

Air Force scientists and engineers continually interact with warfighters to understand their technology needs. The Air Force S&T Program addresses these needs by leading and harnessing innovation across service laboratories, government agencies, industry, and academia. These efforts mitigate risk and create the foundation for new capability concepts.

TECHNOLOGY AREA	FOCUS
Air Vehicles	Aeronautical sciences, control sciences, structures and integration
Directed Energy	High-power microwaves, lasers, beam control, space situational awareness, and effects modeling and simulation
Human Performance	Human capabilities, vulnerabilities and effectiveness; warfighter training; operator and weapons systems integration; protection of personnel; and sustainment of human operations
Information	Information processing, fusion, exploitation, communications and networking; information management; advanced computing architectures; cyber operations; and command and control across air, space and cyberspace
Materials and Manufacturing	Materials and processes, materials applications, manufacturing technologies, agile airbase engineering, and quick-reaction systems support for materials-related acquisition or maintenance issues
Munitions	Fuze technology; munitions energetic materials; damage mechanisms science; terminal seeker sciences; munitions aerodynamics, guidance, navigation and control; and munitions system effects science
Propulsion	Turbine and rocket engines, advanced propulsion systems, system-level thermal management, and propulsion fuels and propellants
Sensors	Air and space reconnaissance, surveillance, precision engagement, and electronic warfare
Space Vehicles	Radiation-hardened electronics, space power, space structures and control, space-based sensing, space environmental effects, Integrated space experiments

AFRL applies a three-phase approach to address specific needs. In the first phase, scientists and engineers work with Air Force major commands and centers to understand their priorities and constraints. In the second phase, AFRL draws upon its technical competencies to develop potential solutions. In the final phase, potential solutions are reviewed with the customer to determine which need/solution combinations will be funded. The highest priority combinations are then matured in AFRL for transition to the warfighter.

Technology transition can range from a single low-cost part, like a solar cell, to large complex sub-systems. Major transition efforts, Advanced Technology Demonstrations, are guided by a general-level council consisting of representatives from the acquisition, operational, and laboratory communities. Key technology transition efforts include:

- **Low-observable repair** techniques and procedures that will drastically reduce the sustainment cost of the service's premier airborne systems.
- **"Radiation hardened by design"** tools, techniques, and procedures that will increase computing speed and affordability of space assets by enabling commercial chip foundries to produce radiation hardened electronics on existing production lines.
- **Sense-and-avoid system** for the Air Force's Global Hawk, U.S. Navy's Broad Area Maritime System, and U.S. Army's Shadow that will enable manned and remotely piloted aircraft to operate more effectively together in congested environments.
- **Propulsion sustainment** technologies that will enhance operational capability and reduce ownership cost of fielded systems.
- **Interactive supercomputers** composed of commercial hardware clusters that will rapidly and affordably transform sensor data into decision quality information.

The Air Force S&T Program also integrates multiple technologies to create and demonstrate new capability concepts for the service. It can take several years of research to mature and integrate revolutionary technology for inclusion in a "capability concept." The following section highlights the most mature and highest-priority capability concepts.

3.3 CAPABILITY CONCEPTS

In collaboration with Headquarters Air Force, major commands and centers, AFRL has defined a balanced set of capability concepts that support known warfighter needs, mitigate risk from emerging threats, and cover the full range of maturity and degree of customer commitment to transition. Capability concepts are clearly defined S&T efforts with schedules aligned with customer needs. In other words, these efforts transition technology when it is needed by the customer.

The most mature AFRL capability concepts, and those with the most customer commitment, are called "flagships." A flagship has clearly defined deliverables and key performance parameters that have been agreed upon by the customer. Flagships are 1) AFRL's top priorities for transition; 2) championed by a user; and 3) endorsed through the Air Force Requirements Oversight Council (AFROC).

In 2010, the AFROC commissioned three AFRL flagship programs: the High Velocity Penetrating Weapon (HVPW), the Responsive Reusable Rocket Booster System for Space Access (RBS) and the Selective Cyber Operation Technology Integration (SCOTI).

High Velocity Penetrating Weapon

The Air Force's next-generation HVPW will hold increased numbers of threat targets at risk, even as foreign governments develop harder and more deeply buried facilities. Advanced technologies, developed by the S&T Program in collaboration with industrial partners, will enhance weapon kinematics, ensure precision guidance in contested environments, and dramatically reduce the size of the weapon. As a result, future fighters will be able to deliver threat-neutralizing capabilities currently associated only with the bomber fleet.

Responsive Reusable Rocket Booster System for Space Access

Current Air Force space launches are expensive and require years of preparation. Moreover, the costs of existing systems are increasing substantially as they age. The RBS will overcome these limitations by demonstrating the feasibility of a space-launch capability that launches a reusable booster vertically; deploys a small, expendable upper stage and payload to orbit; and then lands horizontally, like an aircraft. Through its reusability and aircraft-like operations and maintenance, RBS will reduce costs by at least 50 percent, while dramatically improving operational availability.

Selective Cyber Operation Technology Integration

In cyber warfare, SCOTI will provide the Air Force with the capability to move from small tactical solutions to large-scale strategic operations. The SCOTI program is developing an extensible framework and architecture (takes possible future advances into consideration and attempts to accommodate them) to provide the technology required for the Air Force to accomplish its cyber mission.

In addition to the flagships, AFRL also develops and demonstrates a broad spectrum of capability concepts supporting the Air Force SCFs. These activities ultimately transfer and transition technology to industry that enhances current warfighting systems and accelerate introduction of new, affordable weapon systems.

3.4 RAPID RESPONSE

AFRL supports the current fight through its Rapid Reaction and Innovation Process. In less than a year, the Air Force S&T Program delivers affordable solutions to the warfighter by capitalizing on AFRL's expertise and tightly integrating it with operator knowledge. This process harnesses leading-edge knowledge, commercial off-the-shelf parts and mature technology efforts to rapidly deliver innovative solutions to the warfighter's most urgent needs.

Recent rapid-response development efforts include:

- A small, lightweight infrared emitter for friendly aircraft to identify joint terminal attack controllers on the ground
- A small, man-portable device that enables Special Operations forces to determine ground hardness for landings in remote areas
- A novel, tactical remotely piloted vehicle with an advanced dual sensor for route clearance patrol for the Joint Improvised Explosive Device Defeat Organization
- A wind-measuring dropsonde that unmanned air vehicles (UAV) can pre-deploy to enable single-pass airdrop for Air Mobility Command aircraft
- A maritime unmanned aerial system with wide-area search radar for low-cost, long-range coalition maritime surveillance for U.S. Pacific Command
- A "mock-up" training facility of a modernized Joint Space Operations Center that integrated current and emerging visualization tools, collaboration technologies and human factors design for an urgent DoD need

SECTION 4

INCREASED SCIENCE & TECHNOLOGY EMPHASIS AREAS

The Air Force S&T Strategy identified key increased emphasis areas that are needed to address the changing nature of military and economic threats to the nation. In some of these areas, the Air Force is increasing core S&T funding; in others, the service is aggressively pursuing partnerships with the other services and federal agencies. The following sections identify the broad nature of work in these increased emphasis areas.

4.1 LEGACY SYSTEM SUSTAINMENT, AFFORDABILITY AND AVAILABILITY

Low Observables Maintainability

Non-Destructive Inspection

Automated Inspection

By necessity, the Air Force operates its weapon systems well outside their original design lives, flight envelopes and mission profiles, creating sustainment issues that, if not well managed, lead to significant degradation of reliability, affordability and availability of Air Force assets. The Air Force S&T program works on three fronts to mitigate these issues now and in the future.

For issues with the fielded, operational fleet, the S&T program dedicates expert personnel and specialized facilities to rapidly analyze and resolve problems ranging from excessive cost to grounded planes. This is the front line of the program, which not only transitions solutions, but informs the technology and acquisition community of problems needing longer-term solutions.

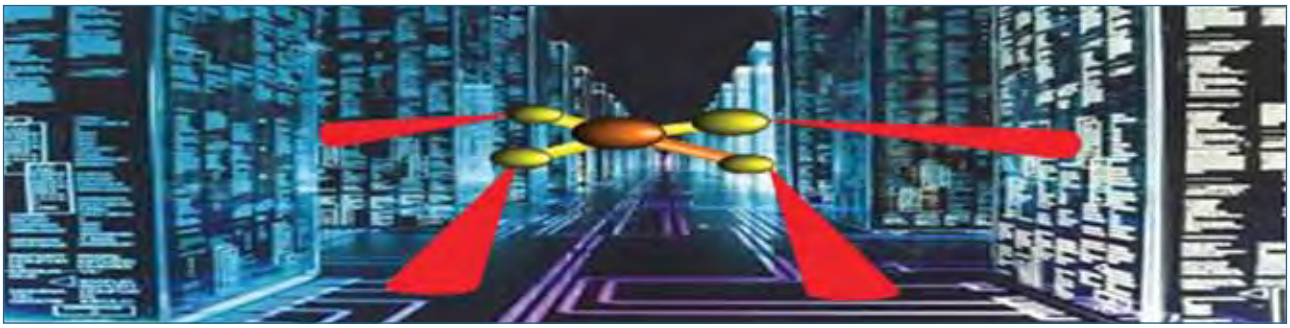
At the command and depot level, the High Velocity Maintenance effort exploits industry practices, lean concepts and advanced non-destructive evaluation methods to make maintenance processes more predictable and reliable. The Condition-Based Maintenance Plus program exploits data collection and analysis technologies to provide decision makers near-complete insight into the fitness of individual platforms, systems in theater, and even an entire global fleet.

Finally, to mitigate problems before they ever arise, the S&T Program is delivering methodologies and tools to ensure new equipment, components and upgrades for legacy systems account for sustainability and affordability "up front" and to cut costs and time out of the design and validation phase. This effort exploits advances in physics-based modeling and probabilistic methods to enable a truly robust design approach.

Objectives

- Support component life extension and improvement programs
- Develop materials and processes that significantly reduce low-observable coating maintenance
- Develop innovative non-destructive evaluation/inspection technologies
- Develop robust, affordable structural materials and concepts
- Develop materials and procedures to mitigate corrosion issues
- Develop physics-based life cycle models
- Significantly enhance proactive health management technologies

4.2 REDUCE CYBER VULNERABILITIES



Resilient Cyber Mission Assurance

In today's cyber environment, Air Force weapon systems are increasingly dependent on integrated, networked computer technology. Much of this technology relies on commercially developed hardware and software, including foreign manufacturers and suppliers. Adversaries recognize the potential vulnerabilities that can be introduced by such a reliance on commercial technology and may exploit them at low costs and with relative impunity. For many years, the Air Force has sought control of these vulnerabilities by preventing adversaries from entering computer networks and other cyber-accessible systems. However, despite these extensive efforts, the pace of advancement of cyber technology means adversaries may still access our cyber-based systems. Therefore, the Air Force is dramatically shifting its focus from cyber defense to cyber-resilient, mission-assured systems that will allow the Air Force to fight through cyber attacks and in contested cyberspace environments.

Objectives

- Research and identify mission-critical functions across the Air Force enterprise
- Perform research and development to support increased domain operations in contested or denied environments
- Develop technologies to identify cyber vulnerabilities, hidden interdependences and causal relationships related to cyber attack methods
- Develop technology to aid human decision-makers in achieving a desired outcome across multiple courses of action
- Develop autonomous decision-support tools that can react quickly to limit the effects of cyber attacks
- Develop technologies that enable "fight through" capabilities
- Develop tamper-proof technologies that can attest to the integrity of a device with high assurance
- Develop agile networks that rapidly, randomly, and continually relocate to avoid detection, reconnaissance, and cyber attacks

4.3 SUPPORT NUCLEAR ENTERPRISE

Advanced Ballistic Missile Guidance Technology

Advanced Rocket Propulsion Technology

Advanced Thermal Protection Materials

Missile Site Security

Nuclear deterrence is the ability to deter by air, land or sea our adversaries from threatening the survival of the United States or its vital interests with nuclear weapons, and to respond appropriately with nuclear options, if required. This deterrence capability is a cornerstone for the United States' defense. The Air Force has the key responsibility of maintaining the land- and air-based elements of this deterrence. It must simultaneously sustain the current nuclear capabilities while laying the foundation for future upgrades and replacements. The Air Force is developing and transitioning key technologies to support current nuclear-capable air and missile systems, command and control, and other ground and support systems.

The AFRL plan is to focus investment in critical nuclear deterrence areas while synergistically leveraging technology advances in other areas, such as command and control. To this end, its S&T investments must holistically address critical aging systems, infrastructure and future systems. While AFRL does not have the responsibility for nuclear weapons, it does have the expertise to develop new technologies in support of nuclear systems, such as advanced ballistic missile guidance technology, advanced rocket propulsion technology, advanced thermal protection materials, and missile site security.

Objectives

- Land-based elements
  - Develop technologies enabling unaided missile guidance with Peacekeeper-like accuracy and lower costs
  - Develop advanced rocket propulsion technologies to increase performance, reduce weight, and improve motor reliability
  - Develop advanced aging and surveillance technologies for rocket motors
  - Develop advanced technologies to increase security of strategic asset sites and provide better site situational awareness
  - Develop materials and procedures that reduce manufacturing costs of advanced thermal protection systems
- Air-based elements
  - Develop technologies that enhance encryption, laser communications, wireless and wired communications, and data fusion
  - Develop high Mach turbine engines and advanced materials
  - Develop advanced turbine and scramjet engines, inlets/nozzles, supersonic exhaust
  - Develop low-observable materials and composite airframe concepts

4.4 AUTONOMOUS SYSTEMS

Sense and Avoid *Cooperative Control* *Autonomous Launch and Return*

The Air Force is challenged by the enormous data volumes, decision speeds and workload needed to control advanced weapon systems. Flexible, autonomous technologies can replace human functions, in whole or in part, can substantially reduce manpower workload and allow the operator to understand and influence the larger picture. However, these technologies will also require entirely new methods for enabling trust in that level of autonomy. Therefore, the Air Force is increasing emphasis on developing effective, flexible, fault-tolerant autonomous systems; natural, adaptive human-machine interaction; and timely, efficient certification and trust of autonomous systems.

To maximize effective, affordable use of both humans and machines in warfighting systems through advanced autonomy and human-machine interaction, the Air Force is growing its internal capabilities and external teaming in autonomous decision-making in the areas of sensors, weapons, vehicle control, human systems, and command and control. For instance, in partnership with the FAA and NASA, AFRL is developing technologies for the safe operation of unmanned aircraft, where the human operator interacts with autonomous operations through supervisory control technologies. In partnership with other national research organizations, the laboratory is developing advanced verification and validation methods for autonomous systems, with a focus on unmanned aircraft. Adaptability and resilience is also critical to the efficiency and effectiveness of autonomous systems.

Objectives

- Develop collaborative systems control technologies that enhance air, space, and cyber autonomy and teaming
- Develop technologies that enhance terminal area and sense-and-avoid operations
- Develop automated information management and decision-support tools
- Demonstrate scalable, integrated, and common interfaces that enhance operator performance by improving human-machine interfaces
- Develop complex software verification and validation and certification tools that provide "trust in autonomy"

4.5 HUMAN PERFORMANCE AUGMENTATION

Enhanced Battlefield Operations *Cognitive Performance Optimization* *Advanced Training Systems*

Human performance augmentation technologies can increase vigilance and optimize situational awareness. They also increase mission effectiveness by enhancing individual and group performance, reducing learning curves, and providing simulated combat training in safe environments. Therefore, the Air Force is increasing emphasis on effective use of humans in warfighting systems through advancements in sensory, cognitive and physical abilities.

It is focusing on research that helps humans and machines interact more closely through improved interfaces. For instance, AFRL is augmenting live-range training with virtual reality for added fidelity, density and realism. It is pursuing transcranial stimulation research that substantially enhances attention and improves learning. Its cognitive resiliency research examines emotional responses to combat stress to enhance performance. Human performance research will also address physical and biological interventions that may enhance and maximize a warfighter's cognition, and improve physical performance, during military operations.

Objectives

- Performance
  - Modulate and track performance biomarkers to enhance cognition, learning, physical performance and stressor responses
  - Advance cognitive workload measurement and optimization
- Training
  - Advance cognitive modeling, synthetic teammates, simulation-based cognitive readiness analysis, performance tracking and prediction algorithm research
  - Develop technologies enhancing live, virtual and constructive training methods

4.6 ROBUST SITUATIONAL AWARENESS

Advanced Threat Track and Identification

Layered C4ISR

Small Unmanned Aerial Systems

The variety of information available from widely distributed ISR sensors is tempered by the technological hurdles of incompatible data formats, bandwidth limitations and multi-level security. As the amount of sensor data increases, it becomes more challenging for human analysts to quickly identify the most salient information. Therefore, the Air Force is increasing emphasis on developing and deploying technologies that improve situational awareness across all domains for decision-makers through trusted, on-demand sensor information available anytime, anywhere in the battlespace.

The Air Force S&T Program is developing and demonstrating enabling technologies for "layered" intelligence, surveillance and intelligence for command, control, communications, and computers (Layered C4ISR). Layered C4ISR will improve the situational awareness of the decision-maker by delivering processed, multi-source, multi-spectral and multi-dimensional (cultural, environmental, etc.) information for making decisions, regardless of location. Layered C4ISR expands upon the current state-of-the-art in sensing by including worldwide broadband improvements in communications network infrastructure and sensors for space situational awareness. The goal of Layered C4ISR is to provide an architecture where customers can provide, or request, information tailored to their needs while not worrying about the specific communications path that information must traverse. The starting point for a number of these technology developments will be capability gaps identified by the SCF process owners.

Objectives

Develop technologies that enable:

- Efficient, autonomous processing, exploitation, and dissemination of ISR data
- Robust, trustworthy, and available communication links
- Timely/actionable space object identification and characterization
- Persistent, multi-phenomenology sensing, particularly of difficult/denied targets
- Data formats that move seamlessly between platforms and operating systems
- Decision/target quality sensor info available on demand
- Enhanced forecasting – identifying human behavior patterns to determine threat actions

4.7 LONG RANGE PRECISION STRIKE

High-Speed Weapon Systems *Future Strike Aircraft*

In today's global environment, potential adversaries are emerging who are capable of denying the United States access to forward bases, degrading communications and surveillance, limiting the maneuverability of our naval forces, and limiting the effectiveness of current strike systems.

The service plans to address these threats by developing new systems, and upgrading existing systems, with mature technologies. The Air Force S&T Program plays a vital role in mitigating future risk by developing and demonstrating new S&T-based capabilities that can be harnessed if adversaries deploy new capabilities faster or more effectively than expected.

Air Force S&T goals in these areas include development of high-speed missiles and aircraft. This family of systems will be a collection of advanced capabilities, platforms and munitions for use against high value, time-sensitive targets in anti-access, or denied, environments.

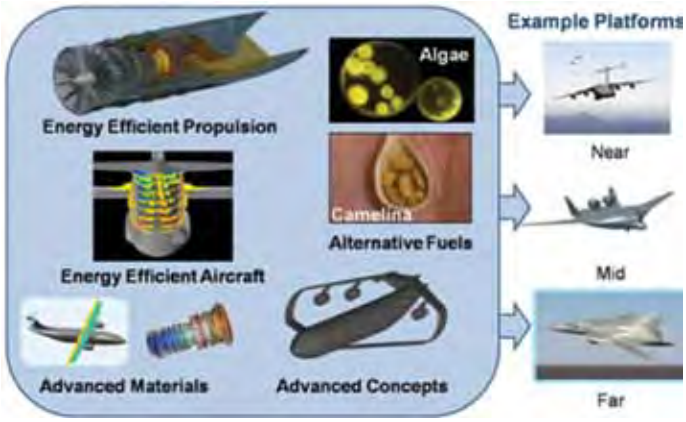
To minimize future risk, the S&T Program is simultaneously developing enabling technologies for individual system components and for optimally integrating the components into a long-range strike system. AFRL has initiated investigations into effective integration of these new platforms and concepts into a larger family of systems. Continued emphasis on collaboration with the warfighter and industry partners will allow AFRL to capitalize on technological advances and optimize component systems for long-range precision strike.

Objectives

Develop technologies that enable:

- High-speed weapon system integration and demonstration
- High-speed propulsion systems
  - Efficient high-speed expendable propulsion
  - Robust, reusable scramjet
  - Fuel efficient turbine engines
  - Turbine-based combined cycle engines
- Low cost, lightweight, high-temperature structures
- High-speed weapon release
- Precision selectable-effects warhead
- Advanced guidance for surface targets
- Precision laser and high power microwave weapons for ultra-high precision engagements at the "speed of light"

4.8 REDUCE ENERGY DEPENDENCY



Energy is central to all aspects of the Air Force's mission, making energy security and management critical to Air Force readiness. The Air Force uses more than two billion gallons of fuel each year, which accounts for about 80 percent of the total Air Force energy usage. Therefore, the Air Force is increasing emphasis on the discovery, development and integration of technologies for energy-efficient warfighter capabilities and assured energy supplies for current and future aerospace forces.

The 2010 Air Force Energy Plan outlines three major objectives: 1) increase supply by creating domestic supplies, including renewable and alternative energy; 2) reduce demand through energy efficiency and conservation; and 3) change the culture so that Airmen make energy a consideration in everything they do.

AFRL responded to this guidance by establishing a dedicated S&T Energy Office. This office leads development of Air Force S&T Energy strategy, interfaces with other national-level energy offices, and facilitates technology transition by working with the major commands to match emerging technologies with capability requirements. It also identifies high-payoff S&T programs for future funding. The AFRL Energy Plan will address near-, mid-, and far-term energy requirements for both the legacy fleet and emerging platforms.

Objectives

- Increase supply
  - Investigate and develop alternative energy and power generation sources for Air Force applications
  - Explore energy harvest and reclamation
  - Assess alternative fuels for Air Force use
- Reduce demand
  - Develop affordable, high-efficiency turbine engines
  - Develop efficient small scale propulsion for UAV applications
  - Develop advanced materials and structural concepts for lightweight, high- temperature, high-strength components
  - Develop advanced analysis and modeling tools for improved aircraft and engine design, systems integration, and more efficient flight operations
- Change the culture
  - Apply systems engineering to ensure energy consideration are included in AFRL technology development efforts

SECTION 5

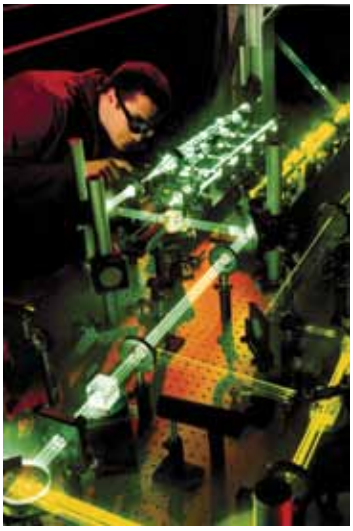
RETAIN AND SHAPE CRITICAL COMPETENCIES

The success of the Air Force S&T Program depends upon an agile, capable workforce that leads cutting-edge research, explores emerging technology areas, and promotes innovation across government, industry and academia. To enhance critical competencies, AFRL is increasing the amount of in-house research in its world-class facilities, expanding its cyber workforce, and fostering the next generation of scientists and engineers (S&Es) by sponsoring science, technology, engineering and mathematics (STEM) activities in schools and universities.

Figure 2. Select Air Force S&T Core Technical Competencies

5.1 INCREASE IN-HOUSE BASIC RESEARCH

The Air Force S&T Program attracts and retains high-quality professionals by providing exciting opportunities to work on promising research that benefits the nation. By increasing the level of in-house basic research, the Air Force will enhance its foundation of technical expertise supporting the nation.



A strong in-house program is crucial to the development and maintenance of AFRL's organic core competencies (*Figure 2*). In-house research gives AFRL's S&Es an opportunity to discover and to develop transformational technologies that, while high risk, will take the Air Force into new revolutionary areas.

Objectives

- Increase in-house research to 30 percent of the basic research budget
- Enhance core competencies by increasing hours that bench-level scientists dedicate to in-house research
- Increase hiring of scientists and engineers with advanced degrees

5.2 ENHANCE CYBER WORKFORCE

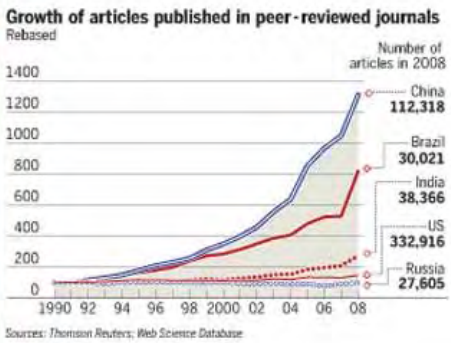
To be effective in the cyber realm, the Air Force must ensure its organic workforce has the necessary skills to develop mission-critical capabilities for secure operations in cyberspace.

AFRL's goal is to ensure the Air Force of today and the future has a professional cadre educated in the science of information assurance. They must be prepared to develop the technology required to operate in a contested cyber domain and to assure success of critical military missions in cyberspace. In collaboration with government, industry and academic partners, the laboratory is developing a robust approach to cyber professional education by encouraging its organic workforce to pursue advanced degrees in cyber engineering, with an emphasis on discrete mathematics, cryptography and networking. It is also developing strategies to assess cyber education methods and incorporate the best strategies into in-house education programs, such as the Advanced Cyber Education program for officers-in-training and current personnel (the program was successfully transitioned to the Air Force Institute of Technology). AFRL has also established university centers of excellence in cloud computing, to focus on this leading-edge cyber technology.

Objectives

- Increase the number of personnel trained in the science of information assurance
- Emphasize degrees in cyber-related engineering and information science fields
- Sponsor university centers of excellence that focus on leading-edge cyber technology
- Develop scientifically based methods for enhancing cyber operator selection and training
- Increase recruiting at key universities and conferences

5.3 SUPPORT AIR FORCE STEM INITIATIVES



In a world environment increasingly competitive in research, the challenge for the Air Force is to maintain sufficient numbers of highly skilled scientists and engineers who can pursue the critical research that will prevent technological surprise of our warfighters. To this end, the Air Force has developed robust and innovative STEM (science, technology, engineering and mathematics) programs to ensure a continuous flow of technically competent Airmen into the Air Force.

The Air Force enterprise approach is to increase the awareness and importance of STEM by 1) fostering scientific discovery and innovation in schools and universities; 2) identifying current and future STEM workforce needs and increasing the diversity of participants in STEM programs; 3) identifying programs and best practices that attract and retain world-class STEM talent; and 4) developing a systematic approach to coordinate STEM education and outreach programs across the Air Force. In addition, the Air Force is establishing an Air Force STEM Office to develop and coordinate policy, processes and outreach activities.

AFRL will align its STEM initiatives with the vision and goals of Bright Horizons, the Air Force's strategic roadmap for managing mission-critical STEM capabilities. AFRL also currently sponsors major outreach initiatives that reach more than 30,000 students annually, including the Wright Scholars, Mars Mission, Space Scholars, Cyber Patriot and Air Camp activities. These activities help educate students on the Air Force's S&T needs and career opportunities.

Objectives

- Help stand up Air Force STEM outreach and coordination office
- Formulate Air Force S&T Program STEM-related manpower requirements in order to maintain a highly competent, diversified and agile workforce
- Pursue strategic partnerships and outreach activities with our schools, universities, sister services, professional associations and other federal agencies
- Build lasting relationships with the best university undergraduate and graduate students who are working in fields relevant to the Air Force through outreach programs

ADDRESS HIGHEST-PRIORITY CAPABILITY NEEDS

SECTION 6

In addressing the Air Force's highest-priority S&T needs, the S&T Program must partner with warfighters, the acquisition and sustainment community, and industry throughout the weapon system's life cycle. These partnerships enable the S&T Program to better understand customer needs, to enhance technology transition and to reduce risk for current and future weapon systems.

6.1 SUPPORT ACQUISITION AND SUSTAINMENT COMMUNITY

An effective and efficient Air Force must agilely incorporate rapidly changing technology into advanced warfighting capabilities. As the Air Force's critical mass of scientists and engineers, AFRL must employ its collective technical intelligence to:

- Create innovative, affordable solutions for the Air Force's most pressing technical challenges, solutions that perform as advertised and are delivered when promised
- Provide trusted, objective and independent technical advice and assessments to both the Air Force materiel enterprise and to senior leadership
- Help customers understand the value of technology as it relates to their current, but also future, missions

To deliver the right technology to the right users at the right time, and in the right form, AFRL fosters technology transition by establishing a common vision and priorities with its customers. These enhanced collaborative relationships help focus limited resources on the most pressing problems encountered by the materiel enterprise.

The Air Force materiel enterprise consists of major commands, centers and AFRL. AFRL seeks to shape materiel enterprise activities by applying science and technology to the "art of the possible" for future battle spaces. At the same time, S&T priorities are shaped by the enterprise's prioritized capability gaps. Concurrent planning across the entire materiel enterprise is essential for convergence to a common, coherent set of materiel priorities. Such collaborative planning helps mitigate transition barriers and synchronize technology insertion across the materiel enterprise.

Objectives

- Proactively engage commands and centers during capability-based analyses, development planning and throughout weapon system's life cycle
- Support well-formed, prioritized S&T needs and solutions (such as flagships and Advanced Technology Demonstrations) that are linked to prioritized capability gaps, have engineering rigor and are linked to a bona fide transition path
- Nurture peer-to-peer customer relations at the strategic, operational and tactical levels
- Translate S&T value propositions into the customer's frame of reference (capability/system/function)
- Promote capability concepts as an integrating construct for the materiel enterprise
- Engage major commands and centers to improve correlation between S&T capability concepts, center plans and SCF capability gaps
- Use Air Force corporate processes to commission S&T capability concepts
- Inject Air Force S&T subject-matter expertise throughout the entire materiel enterprise and requirements community to reduce technical risk

6.2 LEVERAGE INDUSTRY RESEARCH & DEVELOPMENT

By leveraging worldwide S&T investment, the Air Force can reduce the time and expense of developing new technologies, avoid technological surprises, and respond to quickly to emerging, disruptive technologies. The Air Force S&T Program maximizes this leverage by working with both large and small firms to harness innovation for the Airmen of today and tomorrow.

The Air Force Independent Research and Development (IR&D) Program collaboratively shares Air Force technology needs with industry, gathers information on relevant industry IR&D efforts, and helps align industry and Air Force investment plans to address technology gaps and eliminate redundancies.

The Air Force Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Program fosters the development of innovative new technologies at small businesses. The SBIR/STTR Program initiates research on 200 new technologies each year to harness this innovation. The SBIR program also administers a Commercialization Pilot Program, which partners promising companies with prime contractors in order to transition SBIR-developed technologies into industry projects that support Air Force needs. In addition, technology transfer agreements offer industry partners access to advanced Air Force technology (including specialized facilities and equipment), as well as the unique chance to work directly with our top scientists and engineers. Likewise, the Air Force pursues bi- and multi-lateral international cooperative research agreements in technology areas where both the United States and allied partners stand to benefit from collaborative projects.

Objectives

- Increase technological innovation and federal research participation by small business
- Increase technology transfer to industry
- Enhance outreach efforts to ensure that all qualified small businesses are aware of the SBIR program and the many benefits it provides
- Host a wide variety of forums to inform industry of plans for current and future programs
- Expand number and scope of international cooperative research agreements

6.3 DECREASE MANUFACTURING RISK

To decrease manufacturing risks, the Air Force S&T Program is developing technologies to enable production of sustainable world-class weapon systems affordably and quickly.

The aerospace "factory of the future" embraces a vital 21st-century ideal where economy of scope in production is insensitive to volume and specific product characteristics. This factory harnesses advanced technologies such as digital data integration, virtual manufacturing, less complex processes, reconfigurable tooling, self-correcting machines and self-assembly that are platform flexible with real integration of above-shop-floor information. Sustainable manufacturing technologies, implemented at both the shop-floor and enterprise levels, will optimize energy footprints and use environmentally sustainable processes. Small-lot size manufacturing capability will also allow the factory of the future to quickly respond to acquisition requirements and turnaround replacement parts for legacy systems.

Objectives

- Integrate the industrial base enterprise and predict, identify, and react to supply chain issues
- Reduce acquisition cost/risk by moving manufacturing considerations early in the design cycle
- Enable life-cycle value stream management through a cradle-to-cradle digital design thread
- Create the factory of the future with flexible, robust tooling/machine cells for limited part runs

SECTION 7

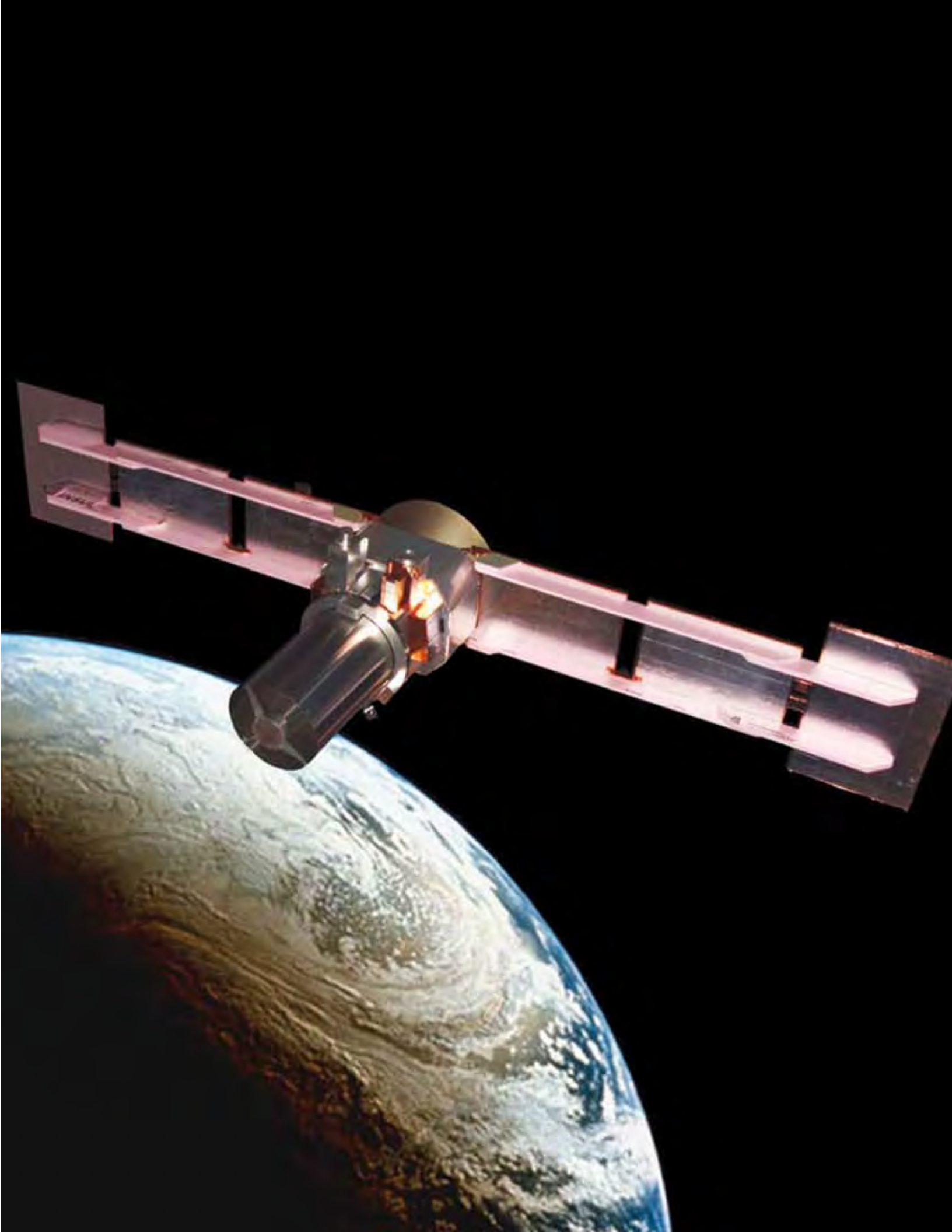
SUMMARY

The Air Force S&T Program has an amazing legacy: Virtually every Air Force system maintains a winning edge by harnessing technology originally discovered, developed and demonstrated by the Air Force S&T Program. The S&T Program is building on this proud legacy by rapidly responding to urgent S&T needs from operational units, developing and demonstrating affordable new capabilities to counter evolving threats, transitioning technologies that enhance weapon system capabilities, and discovering the breakthrough science and knowledge that will ultimately transform the battlefields of the future.

This 2011 Air Force S&T Plan highlights how the service's single research organization, the Air Force Research Laboratory, will:

- Support the current fight while advancing breakthrough S&T for tomorrow's dominant warfighting capabilities
- Execute a balanced, integrated S&T Program that is responsive to Air Force Service Core Functions (SCFs)
- Retain and shape the critical competencies needed to address the full range of S&T product and support capabilities
- Ensure the S&T Program addresses the highest priority capability needs of the Air Force

As a capstone document, the Air Force S&T Plan provides a top-level summary of planned activities. Additional detail on how the service plans to harness S&T to help defend this great nation, and its many allies, can be found in the Air Force SCF Master Plans.

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